THE BUFFALO TRUNK SEWER

1884.

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THE

BUFFALO TRUNK SEWER

IN COURSE OF CONSTRUCTION, JUNE, 1884.

PREPARED FOR

The American Society of Civil Engineers

BUFFALO MEETING,

BY GEORGE E. WARING, JR.,

Consulting Engineer of the Work.

BUFFALO, N. Y.
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1884.

THE BUFFALO TRUNK SEWER.

A suggestion for the construction of an intercepting sewer to keep the filth of the city from flowing into the Hamburg and Erie Canals was originally made by George E. Mann, Esq., then City Engineer. Later, a similar suggestion was made by J. S. Youngs, Esq., City Engineer. Mr. Youngs' project for a sewer equivalent to eleven feet diameter at its head and twelve feet at its outlet was endorsed by Messrs. Moses Lane and Julius Adams, in whose report, (1880,) the following suggestion was made:

"The Main and Hamburg Canal, which it is the first purpose to purify, so far as possible, by cutting off all house sewage now draining into it, would not become by that process alone, a body of clean running water. Its feeble current would not suffice to aerate the water to such an extent as to oxidize the impurities which would still find their way into it to a greater or less extent from various sources on its banks, but it would still require further means of purification. It is therefore proposed that, by the introduction of flushing gates in the intercepting sewer, near this portion of the canal, a large volume of water could at all times, except during excessive storms, be drawn into the intercepting sewer, thus creating a direct current at all times from the lake into the canal."

This important suggestion has been followed in the plan now being executed.

This suggestion and the report of these experts were later submitted to a commission consisting of Messrs. W. Sooy Smith, E. S. Chesbrough and J. Herbert Shedd. This commission approved substantially Mr. Youngs' scheme, but proposed a sewer

of the following sizes: Above Hamburg Street, 9 ft. 8 in.; thence to Genesee Street, 11 ft. 7 in.; thence to the outlet, 11 ft. 11 in.

On the 8th of June, 1882, the Legislature passed an act to create a Board of Commissioners and to provide means for the construction and maintenance of certain sewers in the City of Buffalo. This act gave to the city authority to construct a trunk sewer from a point in Niagara River north of the water-works to a junction with the Mill Race sewer (about four miles distant); also a connecting sewer from the westerly end of the Bird Avenue sewer to connect with the outlet of the trunk sewer at the canal. The distance from the trunk sewer to Bird Avenue sewer is about 5,000 feet.

It authorized the appointment, by the Mayor with the approval of the Council, of a commission of five members. These commissioners have full authority to contract for, and to control the construction of the whole work contemplated by the act, the plans and specifications for the work being first approved by the Council and the appropriation to meet the requisitions of the Commissioners being made by the Council.

Except as so provided, there is no restriction as to the manner in which the commissioners shall perform the work, save that in passing under the canal and harbor, and in doing work along the tow-path of the canal, the plans and methods adopted shall be acceptable to the Superintendent of Public Works and the State Engineer.

For the entire cost of the sewer there are issued by the Mayor and Comptroller "Buffalo Sewer Bonds" payable $150,000 annually until the whole amount shall have been paid. The total cost is not limited.

The commissioners met in June, 1882. September 18, 1882, they submitted to the Common Council a report recommending the construction of a trunk sewer substantially in accordance with preliminary plans furnished by Geo. E. Waring, Jr., Newport, R. I.

The route of the sewer is shown on the accompanying map. It begins at the Mill Race sewer in Seneca Street, following the line of Swan Street to the Terrace, through the Terrace to Court Street, through Court Street to Fourth Street as far as Porter Avenue, thence along the slope of "The Front" and the bank of

the canal to a point near Albany Street, and thence under the Erie Canal and Black Rock Harbor out into Niagara River.

The route followed is substantially the same as that proposed in former plans between Albany Street and the Terrace. It was decided that Swan Street would be cheaper and more practicable than Seneca Street, Exchange Street, or the bank of the canal.

The size adopted is 8 feet 6 inches diameter from Niagara River to the towpath of the canal, thence 8 feet in diameter as far as Hamburg Street; thence 4 feet in diameter to the connection with Mill Race sewer at Hydraulic Street.

Three flushing inlets were provided for, two running from the Hamburg Canal to the trunk sewer (through Hamburg Street and through Chicago Street), the third, from Wilkeson Slip to the main sewer in Court Street. These inlets are to be provided with automatic gates which will ordinarily stand open, but which will close when water in the trunk sewer, during heavy rains, shall have risen higher than the level of the canal.

The city sewers discharging into the Hamburg and Erie Canals are to be intercepted as to their ordinary flow by a 2 foot connecting pipe leading from a depressed chamber in the course of the intercepted sewer to a low point in the invert of the trunk sewer. In the event of these connecting pipes not being able, whether by reason of their size or of the gorging of the trunk sewer, to discharge the full flow, the surplus flows on through the old sewer to a manhole connecting it with the top of the trunk sewer. Any excess beyond the capacity of these two means of entrance flows on through the original sewer to the canal.

The sewer originally recommended was to be equivalent to a circle 12 feet in diameter. This commission in reducing its size to 8 feet, submitted the following observations:

"We have given much thought and our most careful consideration to the size of the sewer, and in submitting to you one eight feet in diameter in place of one twelve feet in diameter, we feel confident that we are providing ample capacity for the sewerage of all the territory to be drained in the future. It is beyond controversy that a sewer of even less size would, for a great many years and for a vastly increased population, receive and dispose of all the sewerage proper, and it is a simple question of how much of the storm water shall be intercepted.

"The sewer of twelve feet in diameter as heretofore proposed did not take all the storm water, but was provided with overflows into the canals. The sewer we propose will not take as much storm water, but will take all of the water which falls in ordinary rains, and it is believed that the overflow into the canals would not occur many times a year. By the ingenious arrangement of Mr. Waring, as shown in the drawings, the filth in the various sewers would be carried off down the trunk sewer by the first rush of the storm water, and when the overflow point is reached, the water which will reach the canals will be so nearly pure that we feel perfectly assured it would not materially contaminate the canal water. In addition to this, as soon as the storm has ceased the current of water will flow from the canal into the sewer and the water thus drawn out will be replaced with fresh water from the slips."

The report is accompanied by an estimate made up in the office of the City Engineer of the cost of construction of the line now to be built.

The estimate for the twelve-foot sewer on the Swan Street line was $1,406,782. The estimate for the eight-foot sewer of the same length is $764,370.

The following is the essential portion of Col. Waring's Preliminary Report which was made the basis of the Commissioners' Report:

NEWPORT, R. I., August 17, 1882.

TO THE BOARD OF SEWER COMMISSIONERS OF THE CITY OF BUFFALO:

Gentlemen,—In compliance with your instructions I have examined the condition of your canals and the circumstances in connection with your present and future sewerage which should influence the construction of the intercepting sewer needed to withhold the putrescible organic matter by which the canal water is now made foul. Concerning the importance of constructing such a sewer I need add nothing to the convincing arguments with which your community is already so familiar. Your citizens must recognize, to a greater degree than a casual visitor can do, the full bearing in this case of the demands of salubrity and of common decency. The question of the day with Buffalo is not at all as to the policy of instituting the proposed reform, only as to the best means for securing it.

The theory on which the earlier recommendations have been based commands full approval. There can be no more perfect means devised for securing the end in view than to establish a strong, active and constant current, in a channel specially provided for the

purpose, sufficient to wash into Niagara River below the intake of the water-works, those foul substances which, under present conditions, are deposited in the canals. In its ability to maintain such a current, Buffalo is especially favored. The means for most copious constant flushing and the absolute solution of the usually difficult question of disposal afforded by your canals and your river, are, so far as I know equaled in no other American town. Filth delivered into the head of the sewer will speedily be shot into the river and practically annihilated. Mr. Chesbrough and Mr. Lane have both accepted this solution of the problem and have demonstrated its completeness.

In the details of their application they differ but slightly, and for the purposes of this discussion it will be well to confine attention to the later of the two projects, which provides for a circular sewer 11 feet and 11 inches in diameter, discharging at Albany Street at a grade which brings the crown of its arch 3 feet above the ordinary level of the river. At its upper end, at Hydraulic Street, it is equal to a circle 9 feet and 8 inches in diameter, and the crown of its arch is there about 6 feet above the ordinary level of Niagara River at Albany Street. Its theoretical dead water line is 1 foot and 4 inches above its invert at its upper end and nearly 6 feet at its lower end. It is arranged to receive a copious inflow from the canal of which the ordinary level is 4 feet and 9 inches above this line. This inflow would establish the desired current. The dry weather flow of the sewers would add something to the volume thus taken from the canal, and deposits at the bottom of the sewer need not be considered. Should such deposits form, they will be safely buried under a living current, and they would be removed with each storm. In short, the proposed sewer can safely be accepted as efficient and satisfactory in its operation.

Reasonable criticism of the proposed work is confined to its cost and to the time which must be occupied in its construction. The sewer is intended to take all of the dry weather flow of the city's drainage and a considerable amount of storm water. As the purpose of its construction relates solely to the withholding of filth from the canal, it is not, in my judgment, of unquestionable propriety to spend so much money and to postpone the benefit to the city for so long a time as would be required for its construction, for the sake of keeping out of the canal a large volume of surface water whose introduction would in no case be serious in its effect. Were it proposed to intercept all of the storm water the conclusion would at least be logical; but as all very heavy storms would cause the sewer to overflow into the canal, it seems prudent to consider the efficacy of the interception of a less amount, including the early flow of severe storms, bearing the foul deposits of the sewers,

and the whole flow of light rains. There is, of course, a certain advantage in intercepting as much of the storm water as possible; but as storm water contains during long rains less and less organic matter as its flow continues and increases, there comes a point at which its inception costs more than it comes to. I think this point is passed in adopting an intercepting sewer for Buffalo which calls for such an extravagant outlay as the one in question. Were it necessary to depend on large volumes of storm water to flush the intercepting sewer itself—as it generally is—the case would be different. But here we do not in the least care for the flushing of occasional storms; we have in the inexhaustible supply of the canal more than we need for such constant flushing as will keep the sewer always clean to its invert, if it be of only ample proportions.

It would seem, therefore, that, while the sewer proposed by the two boards of experts would, undoubtedly, establish a current sufficient to remove the fifth of the city's drainage, as good a practical result may be obtained with a much smaller outlay. It is, no doubt, true that the prosperity of the city is so great that it should not hesitate at any expenditure needed to secure most perfect sanitary conditions, but there will still remain an ample field for profitable investment in sanitary works after the intercepting sewer shall have been finished. Economy—not parsimony—should control each step.

Governed by the foregoing considerations, I recommend such a modification of the intercepting sewer proposed by the two boards of experts as will, in my judgment, secure the desired result at much less cost and in a shorter time.

Description: I recommend the construction of a circular sewer, eight feet in diameter, beginning at the Mill Race sewer in Swan Street, following the line of Swan Street to the Terrace, through the Terrace to Court Street, through Court Street to Fourth Street as far as Porter Avenue, thence along the slope of the Front to the bank of the canal and along the bank to a point near Albany Street, whence its course and grade are changed to carry it under the canal and harbor and into the river.

From its intersection with the Mill Race sewer to the point where the depression to go under the canal begins, near Albany Street, the inclination of the sewer will be 1...4656. The wall of the sewer should be, uniformly throughout its whole length, about thirteen inches thick (three rings). In passing the water-works some special provision such as that indicated in the former specifications, will be necessary.

The invert of the sewer at Albany Street will be 10 feet below the city datum. At its head the invert will be 5.18 feet below the city datum.

At its upper end the invert of the sewer will be 2.43 feet below the ordinary level of the water of the Hamburg Canal. Flushing water may be admitted from the canal in sufficient volume to establish a flow about 2.25 feet deep, and this depth of flow can be substantially maintained throughout the whole length of the sewer by frequent admissions of canal water along its course.

The sewer would intercept all of the sewers which now deliver into the canals throughout its whole course, and it may be made to receive by inexpensive iron siphons under the Hamburg Canal the foul wastes of the industrial establishments on and near its south bank.

The special appliances needed will be the connections for the reception of the flow of the intercepted sewers and the connections for the admission of canal water, with valve gates to close automatically when the flow of sewage rises higher than the water in the canal. The continuation of the intercepted sewers will serve as ventilators and as overflows, relieving the main of its air as its water rises, and delivering into the canal so much of the storm water discharge as cannot be intercepted.

The capacity of an intercepting sewer is subject to material reduction by the amount of involved air carried into it with the rapid flow of intercepted sewers of steep inclination. In order to secure the full effect of the work it will be necessary at points to adopt means for the escape of this air before the flow enters the main.

The tumbling bay and tunnel under the canal, proposed by the first Board of Experts, was properly criticised by their successors. All such devices, leading to a disturbance of the flow, are objectionable and wasteful. The sewer should be carried under the canal by a gradual depression of the main line and on a course of easy reversed curves with only such slight enlargement of its diameter as may be needed to compensate for the changes of direction, reducing the velocity of flow as little as possible.

Capacity: Although less than half as large as the Construction previously recommended, this sewer is a large one and its capacity is very great.

I have submitted my project to W. R. Hutton, Esq., Consulting Engineer, an eminent hydraulician, and have received from him the following estimate of the rate of discharge that will be secured:

Assuming the sewer to receive the intercepted streams at its crown, with no additional head the capacity will be:

At Hamburg Street, 192.2 cubic feet per second.

At Michigan Street, 207.8 cubic feet per second.

At Court Street and the Terrace, 230.0 cubic feet per second.

At a point between Virginia Street and Carolina Street, 249.6 cubic feet per second.

At Porter Avenue, 301.0 cubic feet per second.*

Supposing a population of 500,000 to occupy that portion of the city draining to the intercepting sewer above Court Street and the Terrace with a daily production of sewage of sixty gallons per person, and supposing one quarter of the daily flow to reach the sewer in three hours, this maximum flow would be 92.8 cubic feet per second, leaving a margin for the admission of 137.2 cubic feet of storm water per second, which margin would be increased during the hours of least flow to over 200 cubic feet per second.†

It seems unnecessary to provide for a greater population for the city than would furnish 500,000 residents for this part of its area. It is to be further considered that a very large portion of this area is so nearly level that its surface water will reach the sewer slowly and very incompletely, and that much of it is so low that its surface water will not reach the sewer at all.

All the sewer flow during light and long continued rains will be intercepted, and only a portion of the flow during more severe storms, and this not the earlier and fouler flow, will reach the canal.

The nearer we approach to the outlet of the sewer the greater will be the capacity. The steeper local sewers north of Court Street will have been washed clean and their foul discharge will have gone into the river before the volume coming from the upper end of the main will so occupy it as to force them to overflow into the canal.

Long before the full capacity of the sewer can be required for necessary interception, a radical change will have been made in the character of the local sewerage and street paving and street cleaning of the city, so that the need for intercepting storm water in the interest of the purity of the canal will have mainly ceased.

With a view to a possible future need for a greater capacity in the main sewer than would be furnished by a simple eight-foot culvert, I have considered a future modification of the outlet, using the head of Black Rock harbor on the principle of the jet pump. This can be made effective in increasing the flow in the sewer below the Terrace.

Location: I have given careful attention to the bearings of the arguments in favor of and against the different locations that have been suggested:

The north bank of the Hamburg Canal.

A route through Seneca Street and the Terrace.

A route through Swan Street and the Terrace.

My opinion is very decidedly in favor of the Swan Street line.

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* A recent gauging of all the sewers to be intercepted showed a total dry-weather flow of only 17.9 cubic feet per second.

† By the empirical formula of Julius Adams, Esq., C. E., the capacity of the sewer at Albany Street would be 294.6 feet per second.

It is to be understood, of course, that whichever route is selected, the level at which the sewer is laid will be substantially the same, and that it will intercept as wide an area if laid in Swan Street as it would if laid at the bank of the Hamburg Canal.

The exact course of the sewer from Hydraulic Street to the outlet at Albany Street is laid down on the map accompanying the complete profile.

At Hydraulic Street it would be connected with the direct course of the Mill Race sewer, which sewer would be provided with sufficient overflows near its crown, delivering through its present extension to the head of the Hamburg Canal.

The intercepting sewer being located in Swan Street some means must be adopted for carrying to it the dry-weather flow of the district between this street and the Main and Hamburg Canal. This may be done without modifying the present local sewerage and drainage of this district by intercepting the present sewers with sewers parallel to the canal, and as near to it as convenience in working will allow, which shall connect them with the flushing inlets described below. By this means all of their flow, except during heavy storms, will be carried into the intercepting sewer, and such of them as deliver below the level of the canal will carry a current of canal water toward the main sewer.

It is, however, to be recommended that this district, and the manufacturing establishments south of the canal, be provided with a separate system of sewers to carry all of their foul flow to the intercepting sewer.

Flushing: I have provided the following flushing inlets for leading the water of the canal into the sewer with a view to maintaining as great a flow as possible throughout its whole length:

At Hamburg Street, Chicago Street, Washington Street, Peacock Slip, Genesee Street, Wilkeson Slip, Georgia Street, Virginia Street, Pennsylvania Street, Porter Avenue.*

PRESENT AND FUTURE EFFICIENCY OF THE INTERCEPTING SEWER.

As before stated, I believe that for a long time to come, and probably for all time, the sewer above described will answer every desirable purpose that it is worth while now to provide for. I have arranged for the admission of so much of the flow of every sewer along the route as can find room in a channel having an average capacity of discharge of 125,000 gallons per minute. If the inlets from the canal to the sewer were not protected, there would be a discharge of sewage into the canal whenever the flow line in the sewer rose higher than the level of the canal water. Such out-

* Only the first, second, and sixth of these are now being built.

flow must be prevented by simple swinging gates opening or closing with the current. Their effect would be to retain in the sewer, until the point of overflow at the crown is reached, all that comes to it, causing it to discharge to its full capacity.

It seems to be a controlling argument against the construction of a more costly sewer that any additional future capacity that may be required may be secured by devices of no great cost, whose application may be postponed until the need for them is demonstrated. It will not be questioned that, with an intercepting sewer on Broadway, the main sewer from Hydraulic Street to Court Street will have ample capacity for any duty that it may be called upon to perform. Greatly to increase the capacity of the sewer from the Terrace and Court Street to the outlet, the following additional methods may be adopted:

1. Raising the overflow points at the intersection of the different tributary sewer lines as much as the steep grades of that part of the city will allow without going too far back in the streets, say, for example, six feet at each point of intersection, thus bringing an additional head of six feet to bear on the flow of the sewer.

2. Carrying the outlet to a distance from the bank of the river, delivering into a swift current, with the additional aid of the head of Black Rock harbor, on the principle of the jet pump, and making a proper arrangement of inlets to prevent the admission of air at man-holes near to the outlet, it will be possible greatly to increase the discharge.

The Interior Sewerage of the City: It is no part of the immediate duty with which I am charged to discuss any project for the improvement of the interior sewerage of Buffalo, but it is proper in this connection to call attention to the fact that the work with the execution of which you are now entrusted is, aside from the important duty of purifying the canals, only a means to an end.

It follows as a matter of course, from the hap-hazard, unguided way in which the local sewerage of Buffalo has been carried out, that it can hardly be said to constitute a system at all. The importance of providing, at an early day, some complete and comprehensive plan on which to remodel the sewerage of the closely-built portion of the city can hardly be over-estimated. What plan should be adopted in this connection I have not been called upon to consider. That some radical and universal improvement will soon become necessary cannot be doubted.

The improvement of street surfaces and the removal of street dirt by some other means than leaving it to be washed into sewers by rains is hardly less worthy of the consideration of the public.

When a thorough reform shall have been established concerning these two matters, and not until then, the full benefit of the present proposed outlay will be realized. When the indicated im-

provements shall have been perfected, I think it more likely that the intercepting sewer recommended above will be found to be unnecessarily large than that it will be found to be too small.

Appended hereto I forward plans and provisional specifications for the construction of the intercepting sewer. Before working specifications can be prepared which shall be reliable for estimating the cost of the work, it will be necessary to procure considerably more detailed information than now exists, and to do an amount of work in the preparation of plans for inlets, storm overflows, etc., etc., for which it seems unnecessary at this stage of proceedings to increase your outlay.

Respectfully submitted,

GEO. E. WARING, Jr.

THE TRUNK SEWER AS BEING CONSTRUCTED.

To state the case succinctly, the sewage of Buffalo has hitherto run into the canal and fouled it to such a degree as to create a great nuisance as far down as Lockport. The purpose of the trunk sewer is to cut off and deliver into Niagara River all of this foul flow, except so much as is discharged in the great floods resulting from heavy rains. The sewer is connected by three copious channels with the canals. At the upper end of its eight-foot portion its invert is four feet lower than the usual level of water in the canal. At all times when the capacity of the sewer is not occupied by storm-water sewage it will run to somewhere near half its capacity with canal water.

If the amount drawn from the Hamburg Street and Chicago Street inlets raises the current of the trunk sewer to the springing line of the arch, the volume of its current will equal about 100 cubic feet per second. This will be about equal to the entire prism of the Hamburg Canal between Main Street and Hamburg Street (5400 feet), 100 feet wide and 10 feet deep, once in 15 hours. This will establish a strong, refreshing current from the river and lake to maintain the purity of the canal. Except for the small capacity required for the dry-weather flow of sewage, this free movement of canal water will be continuous. During heavy rains the flushing inlet gates may be closed and the trunk sewer may be filled to its full capacity—at Chicago Street about 200 cubic feet per second; its capacity at Porter Avenue will be about 300 cubic feet per second.

The actual fall, that is, the difference of elevation between the water at the upper end of the Hamburg Canal and the water in Niagara River at the outlet is not constant, depending very much on the effect of different winds on the waters of Lake Erie. It has been assumed to average about 13 inches to the mile.

When its extreme capacity has been reached, any excess in the flow of the intercepted sewers will pass over its crown and flow on to the canal as at present. It is believed that this will occur so seldom and for so short a time that, in view of the constant refreshment of the canal in ordinary weather, it cannot constitute a noticeable objection.*

Attention is called to the depression of the Hamburg inlet, giving its whole area below the normal water level of the canal and insuring delivery of the flushing stream at the side of the trunk sewer with the least practicable loss from friction. In passing the water-works the sewer is to be built of four rings of brick and is to be embedded in puddle.

In passing under the canal the arch of the sewer is of three rings; the whole is encased in concrete, filling the excavation completely, and all mortar, whether in masonry or in concrete, is to be made with Portland cement.

The sewer, depressed for tunneling under the canal, rises sufficiently to enter Niagara River at its bank without such bottom excavation as would be necessary were its depressed course continued horizontally.

* At the office of the Resident Engineer, 44 Chapin Block, there are to be seen complete drawings (blue prints), of all details of the work.

EXTRACTS FROM THE SPECIFICATIONS.

General Conditions.

1. Wherever the words "the Engineer" appear in the specifications, they shall be taken to mean, in all cases, the consulting Engineer of the work, or any subordinate engineer in charge of the part of the work or supply referred to. In case of dispute or doubt between the contractor and the subordinate engineer, reference may be made by either party to the Consulting Engineer, whose decision shall be, in all cases, final.

2. Wherever the words "as indicated" appear in the specifications, they shall be taken to mean, in the manner described in the specifications, or shown in the drawings; or in accordance with the general tenor or intent of either or both of them, or with proper and reasonable deductions therefrom; or according to the decision thereon of "the Engineer," as explained in the foregoing paragraph (1).

A PORTION OF THE SPECIAL STIPULATIONS REGULATING CONTRACTS.

1. The Contractor shall not assign or transfer the contract nor sublet any of the work embraced in it without the written consent of the Board of Sewer Commissioners.

2. The Contractor shall begin the work at such points as the Engineer may direct, and shall conform to his directions as to the order of time in which the different parts of the work shall be done, as well as to all his other instructions as to the mode of doing the same.

3. Whenever the Contractor is not present on the work, orders will be given to the Superintendents or Overseers who may have immediate charge thereof, and shall by them be received and strictly obeyed. And if any person employed on the work shall refuse or neglect to obey the directions of the Engineer or his duly authorized agent, in anything relating to the work, or shall appear to the said Engineer to be incompetent, disorderly, vicious or unfaithful, he shall, upon the requirement of the said Engineer, be at once discharged and not again employed on any part of the work.

4. Any work not herein specified which may be fairly implied as included in the contract, of which the Engineer shall judge, shall be done by the Contractor without extra charge.

6. The Board of Sewer Commissioners shall have the right to make alterations in the location, line, grade, plan, form or dimensions of the work herein contemplated either before or after the beginning of the work. If such alter-

ations diminish the quantity of work to be done, they shall not constitute a claim for damages or for anticipated profits on the work dispensed with; if they increase the amount of work, such increase shall be paid for according to the quantity actually done in equitable proportion to the rate provided to be paid under the contract.

7. The Contractor shall not be entitled to any claim for damages for any hindrance or delay from any cause whatever in the progress of the work or any portion thereof; but such hindrance may entitle said Contractor to an extension of the time for completing this contract sufficient to compensate for the detention, the same to be determined by the Engineer, provided he (the Engineer) shall have immediate notice in writing of the cause of detention and shall consider such cause sufficient.

8. The work embraced in the contract shall be begun within two weeks after written notice so to do shall have been given to the Contractor by the Engineer, and carried on regularly and uninterruptedly thereafter (unless the said Engineer shall otherwise, in writing, specially direct), with such a force as to secure its full completion on or before the thirty-first day of December, 1884, the time of beginning, rate of progress, and time of completion being essential conditions of the contract. And if the Contractor shall fail to complete the work by the time above specified, a sum equal to one-tenth (1-10) of one per cent. of the whole sum agreed to be paid under this contract for each and every day thereafter, until such completion, shall be deducted from the moneys payable under this contract.

10. In any case of dispute between Contractors on adjoining sections, as to the manner of connecting the work, or otherwise, the Engineer shall, in all cases, decide.

SPECIFICATIONS FOR CONSTRUCTION.

Extracts from the Specifications—Omitting much that is not of Special Interest in Connection with this Particular Work.

The Trunk Sewer to be of brick and stone masonry on the location shown on the plan of the work, and according to lines and grades, as indicated, and to be given by the Engineer. All manholes and all structures for interception and overflow and for flushing inlets and for other purposes, as indicated, to be completely constructed and finished, and the street or other ground to be entirely restored, as provided in these specifications. All brick, cement, and iron castings to be bought by the Contractor from the Board of Sewer Commissioners.

The sewer is to be built of the materials, sizes and dimensions, with the connections, on the lines, at the depth and in the manner shown on the plans of the work, the same being entitled "Buffalo Trunk Sewer," and bearing the signature of the Consulting Engineer.

All work during its progress and on its completion shall conform truly to the lines, sections and levels given by the Engineer. All work shall be built in accordance with the intent of the plans and specifications, or either of them, of which intent the Engineer shall be the sole judge.

The ground shall be excavated in open trench of the necessary width and depth or in tunnel of the necessary size. The trench, except in rock excavation, shall be opened from the surface of the ground to the level of the horizontal diameter of the sewer to a uniform width of twelve (12) feet. Below this level the ground shall be excavated to the exact curve of the exterior circumference of the sewer or of other form or depth as the Engineer shall direct. A trench to receive a tile drain shall be excavated to a true line—or if made deeper shall be properly filled to a true line—one foot below the lowest exterior line of the sewer.

The sides of the excavation shall be supported by suitable sheet piling, planking and shoring wherever necessary.

All irregularities in the bottom of the trench shall be filled up to the required level and to the true form of the outside of the sewer, as indicated, with gravel or clean sand, firmly rammed in, or with concrete, as the Engineer shall direct; and where the ground does not afford a sufficiently solid foundation, the Contractor shall excavate the trench to such increased depth as the Engineer may decide to be necessary, and shall then bring it up to the required level and form with such material and in such manner as the Engineer shall determine.

Under the whole length of the sewer a drain shall be laid at a depth of one foot below its lowest exterior line. This drain shall be made of sound pipes or draining tiles laid with uncemented joints, muslin being wrapped around the joints to exclude silt. This drain shall in all cases be laid at least 10 feet in advance of the construction of any part of the sewer, and its flow shall be received in such sumps as the Engineer shall direct, and shall be kept pumped down in such sumps night and day, so that water can never rise into contact with masonry which has not been completed for at least 24 hours. To reduce the amount of pumping as much as possible, the Engineer will order the drain to be stopped and the sump holes in the bottom of the sewer to be built up from time to time as the work progresses; where necessary, in his opinion, however, he may order the drains to be continued in action, pumping stations to be maintained during the execution of the whole work, and such order shall be complied with without extra charge therefor.

In the construction of brick masonry no brick or cement shall be used except such as shall have been sold to the Contractor by the Board of Sewer Commissioners. Only whole bricks will be used, except in closing circles, all bats being immediately removed from the work. Bricks broken after delivery on the work shall be at the loss of the contractor.

All bricks should be thoroughly wet by complete submersion immediately before laying. Every brick shall be laid in a full joint of mortar on its bed, end and side at one operation; in no case is mortar to be slushed or grouted in afterwards.

The invert of the sewer to the spring line shall be worked from templets accurately made according to the dimensions of the sewer and correctly set according to the alignment and grades furnished by the Engineer.

In laying the arch the crown is to be keyed in each layer or ring with stretchers in full joints of mortar. All brick work as it progresses in the invert and, so far as practicable in the arch, must be racked back in courses.

The outer ring of the invert up to the center line of the sewer (or spring of the arch) shall be laid and completed by itself in the manner indicated for a length of 50 feet, or for such shorter length as the Engineer shall from time to time prescribe, in advance of the laying of any part of the second or middle ring. The inner surfaces of the bricks must be laid on a true circle having a radius of 4 feet and 8½ inches, and with inner joints between the bricks of not over 3-16 of an inch, and this outer ring must be supported by proper backing, as indicated, to within 1 foot of its top; but the upper foot of each side of the outer ring must be left without backing until the second ring shall have been laid to the center line of the sewer, when the backing is to be carried to its top and lightly rammed, as indicated The inner surface of this outer ring, properly cleansed and wetted, shall be completely rendered with a thin and perfectly smooth plastering of neat Portland cement, laid on with the trowel as the work progresses, but after the joints shall have been properly and smoothly struck. The inner surface of this outer ring so rendered must be kept as clean as possible until covered by the middle ring. If at any time it shows cracks or other imperfections, the Engineer shall direct

that the defective portion be made good by repairs or renewal, as he shall deem best, and such repairs or renewal shall be effected at the sole cost of the Contractor.

The middle ring shall be laid in the manner indicated inside of the outer ring in such a bedding of mortar as shall carry the inner surface of its bricks to a true circle having a radius of 4 feet 4¼ inches. It shall be laid and completed at least 50 feet, or for such shorter length as the Engineer shall from time to time prescribe, in advance of the laying of any part of the third or inner ring. Its inner surface, properly cleansed and wetted, shall be rendered with Portland cement as directed for the outer ring. It shall in like manner be kept clean, and in case of defect shall be repaired or renewed, if so directed by the Engineer, at the sole cost of the Contractor.

The inner ring shall be laid in the manner indicated, but with bricks of truest form and sharp edges, with inner joints of not more than ⅛ inch, inside of the middle ring in such a bedding of mortar as shall carry the inner surface of its bricks to a true circle having a radius of 4 feet. It shall be laid and completed at least 30 feet, or for such shorter length as the Engineer shall from time to time prescribe, in advance of the setting of the centers for the arch. Its inner surface shall be kept clean, and in case of defect it shall be repaired or renewed, if so directed by the Engineer, at the sole cost of the Contractor.

The centers for the arch of the sewer shall be of such dimensions and so set that brick-work laid upon them will, with the invert, complete a true circle of 4 feet radius. The inner ring of brick-work shall be laid with full mortar joints smoothly struck on the upper side. Only the best and truest select bricks shall be used for this inner ring, and all inner edges must be straight and sharp. They must be laid to inner joints of not more than ¼ inch.

The middle ring shall be laid, as indicated, in a sufficient bed of mortar to bring the outer surface of its bricks to a circle having a radius of 4 feet and 8 inches, and its joints shall be smoothly struck.

The outer ring shall be laid, as indicated, in a sufficient bed of mortar to bring the outer surface of its bricks to a circle having a radius of 5 feet and ¼ inch, and its joints shall be smoothly struck. The outer surface of the arch shall be smoothly rendered with mortar.

The centers shall not be struck until the filling, as indicated, shall have been carried to a height of at least two feet above the top of the sewer.

The centers being struck, all dirt and rubbish being removed from the inside of the sewer, and the whole interior of the sewer being washed perfectly clean, it shall receive, while still wet, a thin and perfectly smooth plastering of neat Portland cement, laid on with the trowel, over its whole inner surface. This plastering must not be soiled, or disturbed, or trodden upon, for at least 48 hours after its application.

In building brick masonry none but careful and skillful brick-layers shall be employed.

When new work is joined to brick masonry on which work has been sus-

pended long enough for the bricks to have become dry, they shall be thoroughly wetted, and the old surface shall be thoroughly cleansed before the brick-laying is recommenced.

As the laying of the outer ring of the sewer progresses from the invert upward to within one foot of the line of the horizontal diameter, the work shall be backed in and carefully packed and rammed by trusty persons, under and around the sewer with proper material and with proper tools, of which the Engineer is to be the judge. In thus filling in under the sewer, the earth or sand shall be faithfully rammed as the work progresses, and in no case shall the number of men back-filling be greater than the number of those ramming, nor shall the layers in any case exceed two inches in thickness. After the middle ring of the sewer shall have been built to the center line, the backing shall be continued in like manner, but only lightly rammed to the height of the brick-work as thus constructed.

After the arch shall have been completed, this lightly-rammed filling shall be thoroughly consolidated, by the use of pointed iron rammers, and the further filling from its surface to a height of one foot above the center line of the sewer, shall be of the finest material, applied in thin layers and thoroughly rammed with pointed iron rammers, the work being done by three men, selected by the Engineer, one man filling and two men ramming. In filling the trench, after the completion of the masonry, from a level one foot above the center line of the sewer, use may be made of the material excavated in opening the trench, but no stone more than four inches in diameter may be deposited nearer to any part of the sewer than one foot. In no part of the filling may the proportion of stone to earth be more than as one to three. All of this portion of the filling must be thoroughly and compactly rammed in layers of not more than six inches, in such manner as the Engineer may direct, and such number of rammers and shovelers shall be employed as he may direct, in proper proportion to the rapidity with which earth is deposited. The Engineer may, in his discretion, require any filling to be rammed in wet.

The sewer is to be constructed in tunnel between Station No. 137 and Station No. 163.

The whole of this part of the work must include three rings of brick-work, laid in full joints of mortar, and having a total thickness of not less than 13 inches.

Subject to the following requirements, and subject to the approval of the Engineer, of the manner in which all parts of the work are executed and carried on, the Contractor will be allowed the largest liberty in selecting the means for driving the tunnel and for backing and supporting the work. Whatever the method or process adopted, there shall first be constructed a complete sewer, having not less than two rings of brick masonry, laid with full joints of mortar, and having together a thickness of not less than 8½ inches, with the joints properly and smoothly struck, of an interior diameter, of not less than 8 feet and 8 inches, and not more than 8 feet and 10 inches. All voids exterior to the circumference of the sewer shall be properly and solidly filled.

As this work is completed all centers and supports of every kind shall be removed, and the sewer so constructed shall be thoroughly cleaned out. Not less than thirty days after such removal of centers and supports, and after such cleansing, the sewer will be tested as to the accuracy of its form and position. If any part of its inner surface is nearer to the true axis of that portion of the sewer as indicated than 4 feet and 4 inches or further from the said axis than 4 feet and 5 inches, such defective portion must be removed and rebuilt, and left without support for thirty days, to test its stability. After thirty days the distance of the inner surface from the true axis of the sewer will be again measured; and the operation shall be repeated as often as may be necessary to secure a wall that has stood within the prescribed limits of distance from the true axis of the sewer for a full period of thirty days.

No extra compensation will on any pretext be allowed for the renewals of the work above provided for; and it is understood by the parties to the agreement that the sum agreed to be paid is to cover all such expenditures in full.

Accuracy having been secured under this test, there will then be laid inside of the sewer a third, or inner ring of brick-work, laid as indicated for work in open cut, with every bed, side and end of every brick laid in a full joint of mortar, and with the joints smoothly and properly struck, having all parts of its inner surface 4 feet from the true axis of the sewer.

This inner ring having been completed not less than 24 hours, all dirt and rubbish shall be removed, the whole interior of the sewer shall be washed perfectly clean, and it shall receive, while still wet, a thin and perfectly smooth plastering of neat Portland cement, laid on with the trowel, over its whole inner surface. This plastering must not be soiled, or disturbed, or trodden upon, for at least 48 hours after its completion.

For a distance of 100 feet in passing the Water-Works (Section B) the sewer is to be constructed of four rings of brick, instead of three rings, with a thickness of wall of 17 inches and with an exterior diameter of 10 feet and 10 inches.

In preparing the ground for the whole of Section B an excavation will be made to the width of 16 feet, from the surface of the ground to the horizontal diameter of the sewer, and below that to at least a half circle with a radius of 8 feet. This excavation will then be filled to the height of the soffit of the sewer to two vertical lines not more than 9 feet apart and below the line of the horizontal diameter of the sewer to a circle having a radius of not less than 4 feet and 6 inches with the best quality of puddling clay carefully and thoroughly puddled, as the Engineer shall direct. As the puddling progresses from the bottom upward the space inside of the 4 feet and 6 inches radius and of the vertical lines 9 feet apart, as above, shall be filled with such earth as the Contractor may select, the same being well compacted to the height of the soffit of the sewer. The whole excavation shall then be filled to the surface and shall remain undisturbed for the space of at least 10 days before being excavated for the construction of the sewer.

The ground being thus prepared, the excavation shall be made and the

sewer and the drain under it shall be constructed in exact accordance with the specifications for the construction of the main line of the sewer, save that for a distance of 100 feet, as above, and as shown in the plan, the walls are to be 4 rings (17 inches) thick, as above.

The channels connecting the flushing-gate chambers with the junction chambers of the Trunk Sewer shall be constructed in all respects in accordance with the specifications for the construction of the Trunk Sewer, as modified by the indications as to size shown in the drawings.

The junction chambers by which these channels are connected with the Trunk Sewer, including the cut-stone masonry connected therewith, shall be constructed in substantial accordance with the specifications as relating to other work of a similar character, especial care and exactness being required for the cut-stone work.

The gate chambers shall be built as shown by the drawings and in the manner, as to brick and stone masonry, as indicated in the specifications, special care being required with reference to all dimension stone.

The gates shall be properly constructed of white oak wood, composition metal and galvanized iron, as shown in the drawings, and shall be properly set in place.

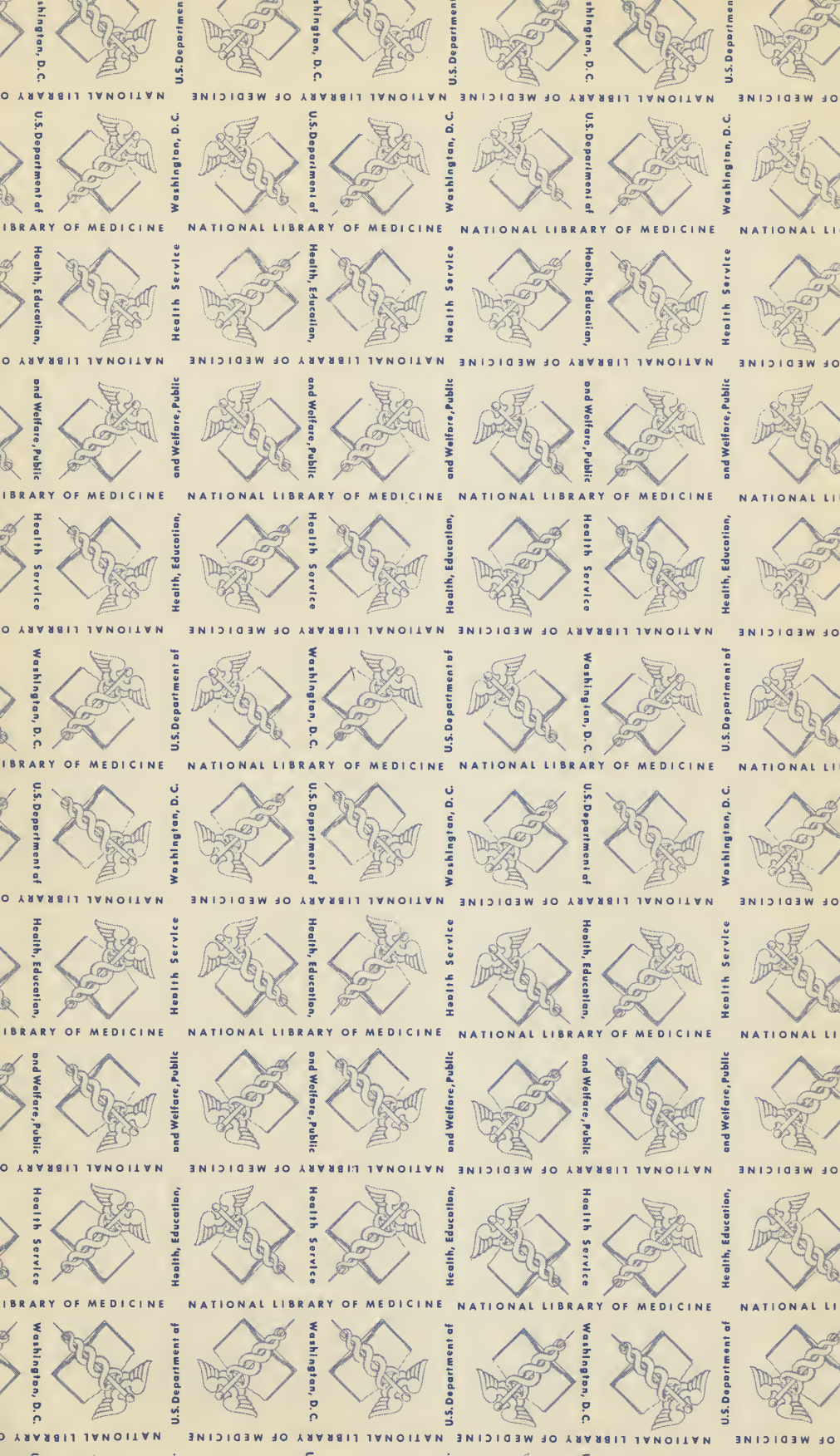
The interception of existing sewers indicated in the list of division of the work into sections shall be carried on, so far as excavation and construction are concerned, in precise conformity to the requirements of the specifications for the construction of the Main Sewer, with the difference of size, number of rings of brick, form of construction, stone work, etc., as indicated by the drawings.

Each inlet sewer will be connected with the Trunk Sewer by cast iron pipes, as indicated by the drawings, which pipes are to be purchased from the Board of Sewer Commissioners.

MATTHEWS, NORTHRUP & CO'S NEW MAP of the CITY of BUFFALO 1884

TRUNK SEWER COMPLETED,
DO. NOT BUILT,
DO. IN TUNNEL.
CANALS,
OLD MILL RACE SEWER

SCALE 1 MILE 1000 0 1000 2000 3000 4000 5000 FT.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